

AUTOMATION OF THE SMART HOUSE SYSTEM-LEVEL DESIGN

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Abstract. In the article the smart house (SH) structural scheme, the general performance algorithm of the SH system, and the SH system model based on colored Petri nets, which enables exploring dynamics of the whole system as well as internal interaction of its main structural and functional subsystems at the system level design, have been developed.

Keywords: smart house, automation, design, system, colored Petri nets

AUTOMATYZACJA SYSTEMOWEGO POZIOMU PROJEKTOWANIA INTELIGENTNEGO DOMU

Streszczenie. W artykule przedstawiono opracowanie schematu strukturalnego inteligentnego domu (ID), ogólny algorytm pracy systemu ID, a także model systemu ID na podstawie kolorowej sieci Petri, co pozwala badać dynamikę zachowania zarówno całego systemu ID, jak i wewnętrznego współdziałania jej głównych podsystemów.

Słowa kluczowe: inteligentny dom, automatyzacja, projektowanie, system, kolorowe sieci Petri

Introduction

The energy saving issues becomes more and more argent in recent days all over the world [15]. One of the possible partial solution to this problem is a widespread use of the smart house technologies (SH) [19] that enables saving energy consumption up to 30%-40% and even more [15]. This technology is named differently: smart house, intelligent, obedient, energy-efficient house and others [2, 6, 11], but the core is a hardware-software system, which ensures comfortable accommodations and possibility of substantial energy savings.

Nowadays there are a lot of companies, which offer modules ready for the implementation of this project [2, 6, 11, 19] and there are many design solutions of smart houses and their components [1, 5, 8, 21, 23, 24].

Various systems for domestic appliances control via the Internet and mobile phones have been created and implemented [19].

Smart houses design as well as the majority of complex technical systems requires application of the block-hierarchical approach [22], which includes such hierarchical levels, namely: system level, subsystems and elements levels. For the analysis of smart house systems and subsystems performance models based on Petri theory [3, 4, 6, 9, 10, 16], which enables integrating different functional components and investigate their joint work, are proposed to be used.

The purpose of the research is the development of the SH system model that provides automation of the inner system processes and the relationship of its main subsystems on the system design level.

1. Development of the SH system model

To ensure the maximum efficiency and functionality, the smart house system should include the following major subsystems: climate-control subsystem, lighting and domestic appliances subsystem, safety and security subsystems and number of other additional subsystems [1, 5, 8, 19, 21, 23, 24].

In order to ensure an effective synchronization mechanism among the main subsystems and components of the developed SH system as well as with the user, the SH system should also include the remote SH controls, the inner SH control module, the central management module and SH subsystems controllers. Taking into account the above components the structural SH system scheme, presented in Fig. 1 has been developed.

The developed structural scheme of the SH system (Fig. 1) includes several major subsystems, namely, climate-control subsystem, lighting and domestic appliances subsystems, safety and security subsystems as well as the monitoring subsystem. Each of the subsystems is responsible for the instant response to

the sensors triggering, indicating the change of the corresponding input SH system parameter, with the aim of the further correction of the system in a given area (areas). Data exchange between the major functional components of the SH system is done through the internal network (Fig. 1).

The system can operate in three modes – in automatic mode, user mode and in the standby mode. In the automatic mode the SH system oversees a response to the change of any input system parameter and running mechanism of the system correction using the appropriate controller (Fig. 1) in automatic mode, and the user is only receiving informational messages about system changes.

The user mode provides synchronization of the SH system with the user through the central management module and remote SH controls using intranet (wired or wireless LAN) or an appropriate Internet connection (Fig. 1).

During this in case of any input parameters changes the corresponding subsystem is activated and the monitoring subsystem forms the information message that requests the user to activate the necessary mechanism for the system correction. Thus, the system correction mechanism is launched exclusively with the user's consent.

The standby mode is intended to temporary suspend (turn off) the SH system performance.

Correction of the SH system is carried out with the use of the appropriate controller (s) (Fig. 1), and actuators.

Each SH subsystem includes the number of individual input and output parameters, sensors and actuators, and is designed for monitoring and correction of the specific SH area.

Sensors are responsible for the collecting input information on the system state, while the actuators are responsible for the implementation of the system correction mechanism in the desired direction.

According to the developed structural scheme (Fig. 1), the general SH system algorithm is presented in the Fig. 2. At the very beginning the system goes into the automatic mode. In case of any event (activation of one or more input parameters) the according associative link of the activated input parameters reference to their domain subsystems and launch of such subsystems are set. In the selected automatic mode the neurcontroler is run [7, 13, 14, 17, 20, 25], which activates the mechanism required for the according SH system parameters correction.

In the user mode the system generates the appropriate request and pends the user permission confirmation to perform the required SH parameters correction, in case of confirmation the neurcontroler is run. After this the system switches to its start state expecting events, or goes into the standby mode and temporary suspension of the system operation.

On the base of the proposed algorithm the SH system model based on colored Petri nets [1-8, 1-9], presented below in Fig. 3, has been developed.

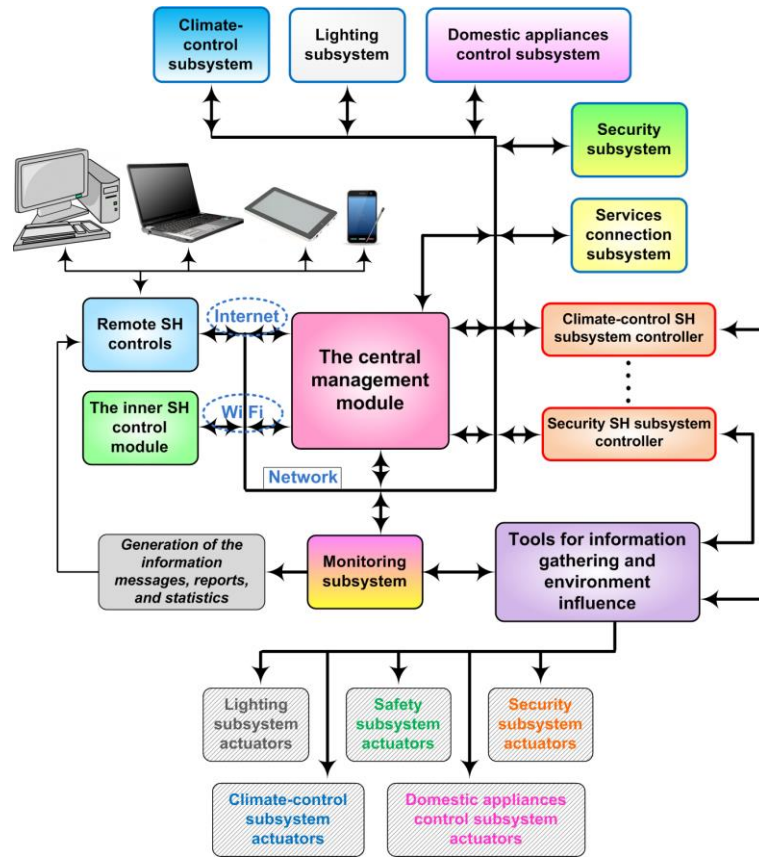


Fig. 1. Structural scheme of the smart house system

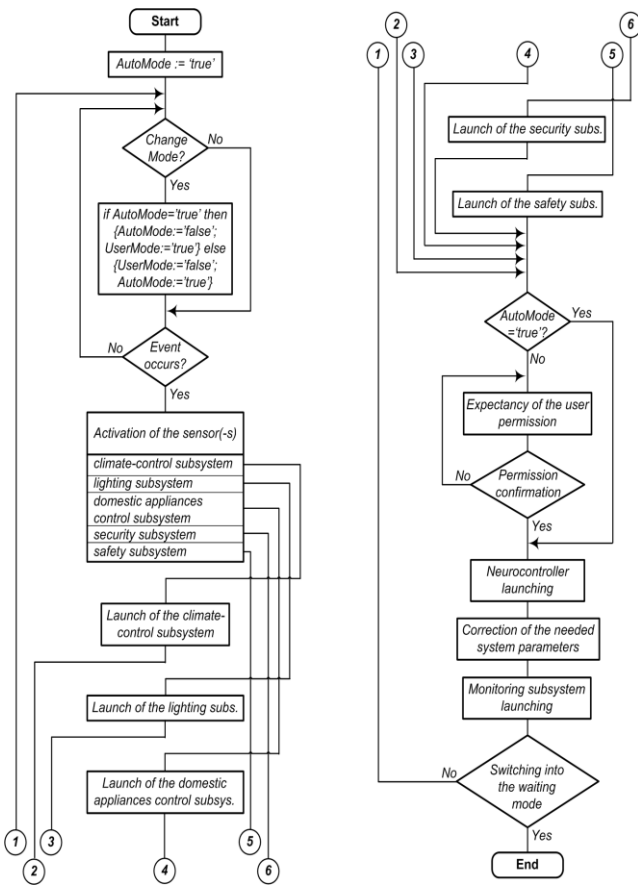


Fig. 2. The general SH system algorithm

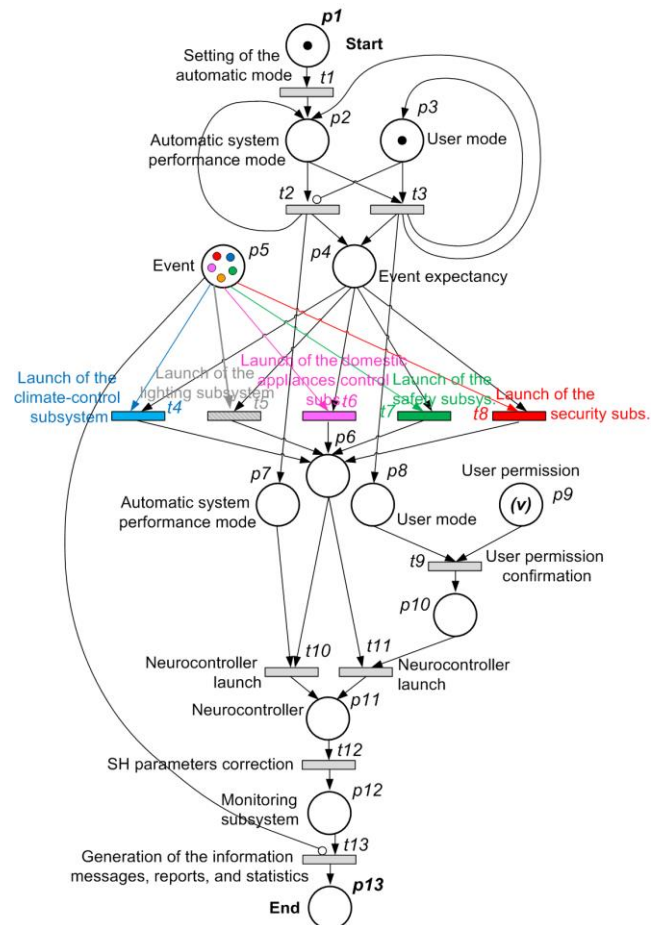


Fig. 3. The SH system model based on colored Petri nets

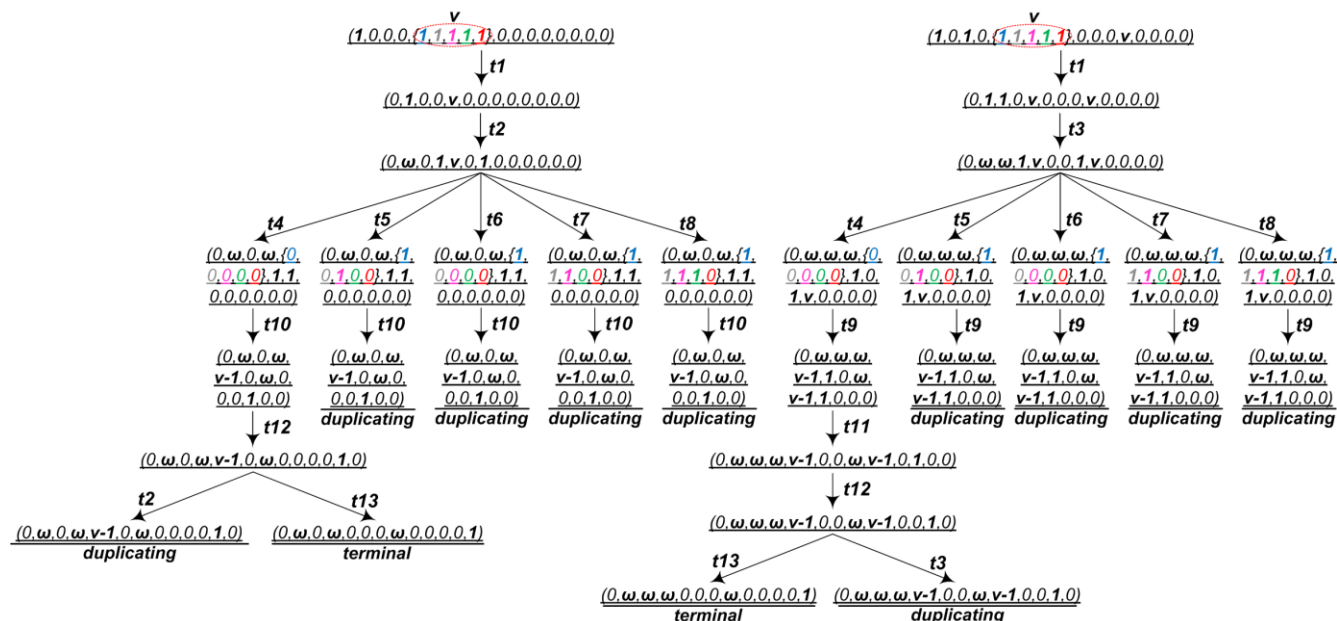


Fig. 4. The state reach graph developed on the base of colored Petri nets SH model

Table 1. The SH model based on colored Petri nets states and their primary purpose

No.	State e	Purpose
p1	Beginning	The state is responsible for launching the model, placing a marker at this position starts the work
p2	The automatic mode of the SH system	The marker state in this position affirms the automatic operation mode of the SH system
p3	The user mode of the SH system	The marker state in this position affirms choice of the user mode of the SH system
p4	Events expectancy	The marker in this position indicates a readiness to identify the active system events
p5	Event	The “event shop” state. This position includes the active events markers that emerged in the different SH subsystems
p6	Readiness to launch the neurocontroller	The marker in this position indicates the system readiness to launch the mechanism of the SH system parameters correction
p7	The automatic mode of the system	The marker in this position indicates the selected automatic mode of the system operation and the subsequent neurocontroller launching
p8	The user mode	The marker in this position affirms the selected user mode of the SH system and waiting for the user permission confirmation to perform the correction of the SH system
p9	The user permission	The marker in this position indicates the user acquaintance with the necessity of making SH system parameters correction in the selected fields and his or her permission to run the neurocontroller
p10	Confirmation of the user permission	The marker in this position affirms the selected user mode of the SH system and the subsequent launch of the neurocontroller
p11	Neurocontroller	The marker in this position indicates the successful neurocontroller launching and moving to the required system parameter correction phase
p12	The monitoring subsystem	The marker in this position affirms the launch of the SH system monitoring subsystem
p13	End	The marker in this position indicates the successful completion of the model performance

Description and purpose of the developed model states and transition are presented below in table 1 and table 2, respectively.

As according to the proposed SH system block diagram (Fig. 1), the system has a number of structural and functional subsystems with different functional purposes, in order to prevent any conflict situations among subsystems, there is a strict levels hierarchy (from the first to fifth, where the 1st has the highest priority) of the basic functional SH subsystems. It is presented below in table 3.

Table 2. The SH model based on colored Petri nets transitions and their primary purpose

No.	Purpose
t1	The launch of the model
t2	Setting of the SH system automatic operation mode
t3	Setting of the SH system user mode
t4	The launch of the climate-control SH subsystem
t5	The launch of the lighting SH subsystems
t6	The launch of the domestic appliance control SH subsystem
t7	The launch of the safety SH subsystem
t8	The launch of the security SH subsystem
t9	Confirmation of the user permission to launch the neurocontroller for the indicated SH parameters correction
t10	Launch of the neurocontroller (in the automatic mode)
t11	Launch of the neurocontroller (in the user mode)
t12	SH parameters correction
t13	Generation of the information messages, reports, and statistics

Table 3. The priority levels hierarchy of the basic functional SH subsystems

Subsystem	Priority level
The security subsystem	1
The safety subsystem	2
The lighting subsystem	3
The domestic appliance management subsystem	4
The climate-control subsystem	5

Thus, according to the proposed hierarchy, the security subsystem has the highest priority, which is responsible for the material values saving and general protection of the SH system against the unauthorized penetration and external influence. In the same time, the climate control subsystem has the lowest priority, primarily due to the high inertia to change the basic parameters of the subsystem. The state reach graph developed on the base of colored Petri nets SH model is depicted below in Fig. 4. Each link of the graph corresponds to a possible state of the developed model. So, built graph represents the reachability of each of the states of the developed model based on colored Petri nets, and it allows to keep the full picture of the behavior of SH system, represented by the developed model, based on colored Petri nets.

2. Conclusions

The work presents the structural scheme of the SH system, the general algorithm of the SH system and the SH system model based on colored Petri nets. The developed structural scheme of the SH system includes a number of key structural and functional subsystems that allow implementing automatic correction of the basic SH parameters for the most comfortable inner climate conditions and maximum energy savings, while providing protection against intruders penetration into the SH, as well as against probable property damage caused by emergency man-made situations (leak of the natural gas, water flowing, fire inside the SH premises, etc.) In order to avoid potential conflicts that may arise among the basic functional subsystems, there is a strict priority levels hierarchy in the SH system.

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